Claims

I claim:

1. A liquid crystal display, comprising

plural liquid crystal picture elements selectively operable to affect light by scattering or absorbing light or by reducing such scattering or absorption of light, and

a separator integral with and between respective picture elements,

said separator being substantially non-selectively operable to affect light.

2. A display element for a projection display, comprising

plural picture elements of volumes of liquid crystal in a medium and selectively operable to scatter or absorb light or to reduce such scattering or absorption, and

an inherent mask between respective picture elements.

3. A display element for a projection display, comprising

plural picture elements of volumes of liquid crystal in a medium, said liquid crystal and medium being cooperative for selective operation to scatter or absorb light or to reduce such scattering or absorption, and

an inherent mask between respective picture elements.

4. A display for a Schlieren projection display system, comprising

plural picture elements of volumes of liquid crystal in a medium, said liquid crystal and medium being cooperative for selective operation to scatter light for projection or to reduce such scattering or absorption, and

a mask between respective picture elements for transmitting light without substantial scattering.

5. A projector, comprising

a display having plural picture elements for selectively scattering light or for reducing the amount of scattering,

a mask cooperative with the display to block transmitted light and to transmit scattered light for projection,

an integral separator between respective picture elements,

said separator being substantially non-scattering with respect to light passing therethrough whereby such light is blocked by said mask.

6. The projector of claim 5, wherein the mask includes a stop to block transmitted light and an aperture to transmit scattered light for projection.

7. A display, comprising

liquid crystal picture elements in spaced relation operable selectively to create an image,

spacer means between respective picture elements forming a grid of spacers and picture elements,

plural electrical drive means in spaced relation for selectively applying electrical input to respective picture elements,

said spacer means being located in relation to the space between respective electrical drive means.

8. A Schlieren optics projector, comprising

a display including

plural elements for selectively transmitting light or scattering light, and

a separator having a substantially constant optical characteristic relative to said respective elements, and

means for discriminating between light scattered by respective elements beyond a prescribed angle and light transmitted by said separator or by light transmitted by said elements without scattering outside such prescribed angle.

9. The projector of claim 8, said means for discriminating comprising a mask.

10. A method of making a display element for a projector, comprising,

dissolving a liquid crystal material in a medium,

curing different portions of the medium differently thereby to allow volumes of liquid crystal to form in respective portions of the medium and to allow portions of the medium to cure substantially without volumes of liquid crystal therein.

11. The method of claim 10, said curing comprising cross-linking.

12. The method of claim 10, said volumes being operative to scatter light or to reduce scattering.

13. The method of claim 10, said curing comprising curing sufficiently slow so lc leaves the medium.

14. The method of claim 10, said curing comprising curing sufficiently fast to create volumes of liquid crystal.

15. The method of claim 10, said curing comprising applying ultraviolet radiation.

16. The method of claim 15, said curing comprising applying a mask to block ultraviolet radiation from areas where volumes are to occur, applying slow cure ultraviolet radiation to exposed areas to get cured areas without liquid crystal, removing said mask and applying fast cure ultraviolet to get volumes with liquid crystal.

17. An electronic display, comprising

plural picture elements for selectively affecting or not affecting incident light,

an electronic drive having plural drive elements for selectively applying an electrical input to respective picture elements,

said picture elements and said drive elements arranged in corresponding patterns, and

a spacer between respective picture elements aligned with respect to space between respective drive elements, said spacer having a substantially constant optical characteristic corresponding to one of the selective operations of said picture elements.

18. A liquid crystal display system, comprising

a substrate having plural electronic drive elements in spaced apart relation,

plural volumes of liquid crystal in a medium, said volumes of liquid crystal arranged in overlying relation to respective electronic drive elements, said volumes of liquid crystal being selectively operable to scatter light or to transmit light without substantial scattering,

a mask between respective groups of volumes of liquid crystal, said mask being in overlying relation to said substrate and between respective electronic drive elements.

19. The invention of claim 18, said mask being substantially transparent.

20. The invention of claim 18, said mask being substantially non-scattering.

21. The invention of claim 18, said volumes being operative to scatter light in the absence of a prescribed input.

22. The invention of claim 18, said volumes being operative to reduce scattering in response to a prescribed input.

23. The invention of claims 1-9 or 17-22, further comprising a source of collimated (parallel) light.

24. The invention of claims 1-4, 7, 10-16 or 18-22, wherein said liquid crystal comprises liquid crystal material having a birefringence of about 0.12 or less.

25. The invention of claims 1-4, 7, 10-16 or 18-22, wherein said liquid crystal device includes a medium having plural volumes containing the liquid crystal material controls the angle of the light scattering as a function of the size of the volumes, and wherein the size of the volumes is about 5 microns or less.

26. The invention of claim 25, wherein the size of the volumes is about 4 microns or less.

27. The invention of claim 26, wherein the size of the volumes is about 3 microns or less.

28. The invention of claims 1-4, 7, 10-16 or 18-22, wherein the liquid crystal in the liquid crystal device is a low birefringence liquid crystal.

29. The invention of claim 28, wherein the birefringence of the liquid crystal in the liquid crystal device is about 0.12 or less.

30. The invention of claim 29, wherein the birefringence of the liquid crystal is about 0.08 or less.

31. The invention of claim 30, wherein the birefringence of the liquid crystal is between about 0.04 and about 0.08.

32. The invention of claims 2-4, 10-16 or 18-22, wherein the volumes of liquid crystal comprise encapsulated liquid crystal.

33. The invention of claims 2-4, 10-16 or 18-22, wherein the volumes of liquid crystal are selected from materials referred to as NCAP, PDLC, or LCPC.

34. The invention of claim 2-4, 10-16 or 18-22, wherein the volumes of liquid crystal comprise liquid crystal material of relatively low birefringence in a

medium that has surfaces to cause scattering of light in the absence of a prescribed input and reduces scattering in response to the prescribed input.

35. The invention of claim 34, wherein the surfaces interact with the liquid crystal material to cause scattering of light.

36. The invention of claim 35, wherein the surfaces interact with the liquid crystal material to cause scattering of light due to a difference between the extraordinary index of refraction of the liquid crystal material and the index of refraction of the material of the surfaces.

37. The invention of claim 34, wherein the prescribed input is electric field.

38. The invention of claim 34, wherein the ordinary index of refraction of the liquid crystal is substantially matched to the index of refraction of the medium.

39. The invention of claims 1-4, 7, 10-16 or 18-22, wherein the liquid crystal has positive dielectric anisotropy.

40. The invention of claims 1-4, 7, 10-16 or 18-22, wherein the liquid crystal is operationally nematic.

41. The invention of claims 1-4, 7, 10-16 or 18-22, wherein the liquid crystal is smectic.

42. The invention of claim 41, wherein the liquid crystal is smectic A liquid crystal.

43. The invention of claims 1-4, 7, 10-16 or 18-22, wherein the liquid crystal is cholesteric.

44. The invention of claim 23, wherein the source of collimated light comprises a light source.

45. The invention of claim 44, wherein the source of collimated light comprises a collimating lens.

46. The invention of claim 23, wherein the source of collimated light comprises a collimating lens.

47. The invention of claims 1-9 or 17-22, further comprising separate projection lens.

48. The invention of claims 1-4, further comprising an aperture for blocking specularly transmitted light and transmitting scattered light, wherein said aperture comprises an annular or ring-like and has a central stop portion.

49. The invention of claim 48, wherein said central stop portion is within the area circumscribed by an annular or ring-like opening portion of said aperture.

50. The invention of claim 48, wherein said central stop portion is substantially centered within the area circumscribed by an annular or ring-like opening portion of said aperture.

51. The invention of claim 48, wherein said stop portion is supported by a spider.

52. The invention of claim 48, wherein the aperture comprises a transparent material supported in a non-transparent support, and wherein the stop portion is supported on or is a nontransparent part of the transparent material.

53. The invention of claims 5 or 9, further comprising projection optics for projecting at least some of the scattered light which is transmitted through the mask.

54. The invention of claim 53, said projection optics comprising a projection lens.

55. The invention of claim 53, wherein the mask comprises a light transmitting area through which scattered light may be transmitted and a stop for stopping the transmission of unscattered light.

56. The invention of claim 55, wherein the radial extent or remote limit or distance of the light transmitting area of the mask is limited by the f number of the projection optics.

57. The invention of claim 56, wherein the mask is absent an external defining element, and the entrance pupil of the projection optics limits the amount of light that is collected from the aperture.

58. The invention of claim 55, said mask further comprising a light blocking means for blocking light transmission radially beyond the light transmitting area.

59. The invention of claim 53, said projection optics comprising plural lenses.

60. The invention of claim 53, said projection optics comprising a reflector.

61. The invention of claims 5 or 9, further comprising projection optics for projecting an image formed by light transmitted through said mask, and wherein the mask is defined by the stop and a light transmitting area adjacent the stop, and wherein the radial extent or remote limit or distance of the light transmitting area of the aperture is limited by the f number of the projection optics.

62. The invention of claims 5 or 9, further comprising projection optics for projecting an image formed by light transmitted through said mask, and wherein the mask is defined by the stop and a light transmitting area adjacent the stop, the aperture is absent an external defining element, and the entrance pupil of the projection optics limits the amount of light that is collected from the aperture.

63. The invention of claims 5 or 9, further comprising projection optics for projecting an image of the display, the image having contrasting relatively brighter and relatively darker portions including relatively brighter portions representative of areas of the display that are scattering light and relatively darker portions representative of areas of the display that are specularly transmitting light.

64. The invention of claim 63, further comprising electrical means for selectively supplying a prescribed input to the liquid crystal to form an image.

65. The invention of claim 64, further comprising circuit means for supplying signals to said electrical means for developing the image.

66. The invention of claim 65, said circuit means comprising a video circuit.

67. The invention of claim 65, said circuit means comprising television circuitry.

68. The invention of claim 65, said circuit means comprising a computer.

69. The invention of claim 65, said electrical means comprising electrodes.

70. The invention of claim 65, said electrical means comprising solid state devices.

71. The invention of claim 65, said electrical means comprising transistors.

72. The invention of claim 65, said electrical means comprising thin film transistors.

73. The invention of claim 23, said source of collimated light and picture elements of the display being arranged in optical path whereby the source delivers the light for one pass through the picture elements.

74. The invention of claim 23, further comprising a reflector at one side of the picture elements of the display, and said source of collimated light and picture elements being arranged in optical path whereby the source delivers the light to the other side of the picture elements and the reflector reflects light back through the picture elements.

75. The invention of claim 74, wherein the amount of scattering effected by the picture elements is about the same for each pass of light through the picture elements and is about twice as much as the scattering effected by a single pass through the picture elements.

76. The invention of claims 1-4, 7 or 18-22, further comprising means for selectively applying electric field across the liquid crystal at respective drive voltages on order of from about 5 to about 10 volts.

77. The invention of claims 1-4, 7 or 18-22, wherein the liquid crystal is nonlight absorbing.

78. The invention of claims 1-4, 7 or 18-22, wherein the liquid crystal is absent light absorbing dye.

79. A projector, comprising

a source of collimated light,

a liquid crystal means for selectively transmitting light or scattering light through a relatively controlled angle, the liquid crystal means comprising relatively low birefringence liquid crystal in a containment medium to form plural picture elements, and the liquid crystal having an ordinary index of refraction substantially matched to the index of refraction of the containment medium,

a mask between respective elements for transmitting light without substantial scattering,

focusing means for focusing the collimated light substantially to a point,

a stop for blocking light directed to that point, and

an opening for transmitting scattered light to form an image beyond that point.

80. The projector of claim 79, said source of collimated light comprising a light source and a collimator for collimating light from the light source.

81. The projector of claim 79, wherein the stop comprises a light conductor for conducting light away from the path of scattered light.

82. The projector of claim 79, wherein said stop comprises a light absorbing stop.

83. The projector of claim 79, wherein said stop is a non-light transmitting stop.

84. The projector of claim 79, wherein the focusing means has an optical axis and said stop is located on the optical axis of the focusing means and is substantially centered on that optical axis.

85. The projector of claim 79, wherein the birefringence of the liquid crystal is about 0.12 or less.

86. The projector of claim 85, wherein the birefringence of the liquid crystal is about 0.08 or less.

87. The projector of claim 86, wherein the birefringence of the liquid crystal is between about 0.04 and about 0.08.

88. The invention of claim 79, wherein said liquid crystal device includes liquid crystal material and controls the angle of the light scattering as a function of the birefringence of the liquid crystal material, and wherein said liquid crystal material has a birefringence of about 0.12 or less.

89. The invention of claim 79, wherein said liquid crystal device includes a medium having plural volumes containing the liquid crystal material controls the angle of the light scattering as a function of the size of the volumes, and wherein the size of the volumes is about 5 microns or less.

90. The invention of claim 89, wherein the size of the volumes is about 4 microns or less.

91. The invention of claim 90, wherein the size of the volumes is about 3 microns or less.

92. The invention of claim 79, wherein the liquid crystal means is encapsulated liquid crystal.

93. The invention of claim 92, wherein the liquid crystal device is selected from materials referred to as NCAP, PDLC, or LCPC.

94. The invention of claim 79, further comprising projection optics for projecting an image of the liquid crystal means, wherein the liquid crystal means comprises liquid crystal material and a medium for cooperating with the liquid crystal material to scatter light under prescribed conditions, the medium having an index of refraction, wherein the index of refraction of the medium and the ordinary index of refraction of the liquid crystal material are about the same and the extraordinary index of refraction of the liquid crystal material is different from the index of refraction of the medium, and wherein the size of the aperture is coordinated with the amount of scattering produced by the liquid crystal means to optimize the contrast of the image.

95. The invention of claim 94, wherein the medium is a containment medium for containing volumes of the liquid crystal material, and wherein the size of the volumes is coordinated with the aperture further to optimize the contrast of the image.

96. The invention of claim 95, wherein the birefringence of the liquid crystal material is about 0.12 or less, and the volumes are about 5 microns or less.

97. A projection system in which an image is formed from nonspecular light, comprising

a collimated light input,

a liquid crystal device including liquid crystal material for selectively specularly transmitting light or non-specularly scattering light,

a mask at selected areas of the liquid crystal device for transmitting light without substantial scattering,

projection optics for receiving non-specularly scattered light for projection,

means to block the specularly transmitted light from projection by the projection optics, and

wherein the angle of non-specular scattering is controlled by limiting the liquid crystal material to a birefringence that is about 0.12 or less.

98. The projection invention of claim 97, wherein the birefringence of the liquid crystal is about 0.08 or less.

99. The invention of claim 98, wherein the birefringence of the liquid crystal is between about 0.04 and about 0.08.

100. A projection system in which an image is formed from nonspecular light, comprising

a collimated light input,

a liquid crystal device including low birefringence liquid crystal material in volumes in a containment medium for selectively specularly transmitting light or non-specularly scattering light,

a mask at selected areas of the liquid crystal device for transmitting light without substantial scattering,

projection optics for receiving non-specularly scattered light for projection,

means to block the specularly transmitted light from projection by the projection optics, and

wherein the angle of non-specular scattering is controlled by limiting the size of the volumes to about 5 microns or less.

101. The invention of claim 100, wherein the angle of non-specular scattering also is controlled by limiting the liquid crystal material to a birefringence that is about 0.12 or less.

102. A method of projecting a relatively high contrast image, comprising

directing collimated light through a liquid crystal device that provides selectively transmitting of light or controlled scattering of light,

locating between respective portions of the liquid crystal device a mask for transmitting light without substantial scattering,

using Schlieren optical system discriminating between transmitted light and scattered light, and

projecting the scattered light to form an optical output.

Add C1

Add C3

Add C2